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Construction of a technology adoption decision-making model and its extension to understanding herd behavior

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ABSTRACT

Decision makers often face challenges during the adoption of technology. Indeed, technology adoption usually occurs sequentially, so observational learning can help the decision makers to reach reasonable decisions. In reality, the decision makers may prefer to adopt a waiting strategy when the situation is equivocal. In this study, we construct a technology adoption model called the G-WB model, where we consider a generalized waiting situation based on the Walden–Browne (WB) model. In our model, herd behavior is a difficult issue, but an information cascade occurs after herding appears. We explore the effect of different parameters on the convergence speed and extend our G-WB model. We also demonstrate that observational learning is a useful strategy during sequential decision making and our model is an optimal version of the WB model, which facilitates a better understanding of herding.

1. Introduction

Information technology and information system (IT/IS) are now indispensable components of our everyday lives, which are important for improving economic development, the efficiency of work, and the quality of life. However, whether IT plays critical roles depends on people actually adopting technology. Bikhchandani et al. [19], Walden and Browne [11], and Banerjee and Fudenberg [3] studied technology adoption from the perspective of social learning. In the real world, decisions are often made in order in many uncertain situations, which is known as sequential decision-making. Considering the cost of information acquisition, every decision maker may possess a small amount of information. Since the information asymmetry that is at least some relevant information is known to some but not all parties, every decision maker may possess different information. In order to make reasonable decision, decision makers usually acquire from others in the local environment, i.e., social learning.

Observational learning is a typical component of social learning. Although observational learning behavior is common, simple, and easily understood, the different approaches to abstract observational learning from real situations may lead to different conclusions. Thus, observational learning models may be based on observing the immediate predecessor, random samples, or aggregation actions.

In this study, we mainly consider the role of aggregation actions in observational learning. Many previous studies have addressed this issue. For example, Banerjee [2] found that observing aggregation actions can lead to herd behaviors, i.e. people will be doing what others are doing, which may result in inefficient outcomes. Bikhchandani et al. [19] claimed that human behavior is based on localized conformity (e.g., Americans act like Americans and Germans act like Germans) and the fragility of mass behavior (e.g., the attitude toward cohabiting unmarried couples has changed over time). These characteristics can also be explained by information cascades, which occur when it is optimal for an individual, having observed the actions of those ahead of him/her, to follow the behavior of the preceding individual without regard to his own information. However, Walden and Browne claimed that the concept of fragility is to some degree an artifact of the model employed by Bikhchandani et al. [19] and that other types of fragility may exist. Furthermore, Gale [7] stated that cascades may be fragile or robust depending on many factors, such as whether the signal is continuous or discrete, whether the action space is discrete or continuous, and whether the decision-making queue is endogenous or otherwise. Smith and Sorensen [16] emphasized

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the difference between information cascades and herd behaviors. In information cascades, the decision makers ignore their private information and copy their predecessors when making decisions. In herd behaviors, the subjects usually make the same decision as others but he/she might not ignore his/her private decisions. Thus, herd behavior is not necessarily the result of an information cascade [5].

Many studies have addressed the learning of aggregation actions, but there are different opinions regarding whether herd behaviors will occur, why herd behaviors might emerge, and the robustness of herd behaviors. The different assumptions regarding observational learning behavior have yielded different results. Bikhchandani et al. [19] proposed a discrete signal binary behavior model, where each decision maker has a binary signal, either H or L, and a binary decision is made about whether to adopt new technology. Walden and Browne [11] developed an observational learning model based on that described by Bikhchandani et al. [19], where they changed discrete signals into continuous signals. Doong and Ho [23] referred to this as the Walden–Browne (WB) model and they discussed it from a dynamic Bayesian network perspective. In the present study, we also consider the WB model. In all previous models, the decision makers are rational and they make once in a lifetime decisions about whether discrete signals or continuous signals are employed. However, the WB model ignores the possibility that a decision maker may prefer to adopt a waiting strategy if their private signal cannot provide sufficient information and the situation is equivocal, before making a reasonable decision after the situation becomes clearer.

Faced with new options, decision makers often stick with the status quo alternative, that is, waiting, doing nothing or maintaining one's current or previous decision [21]. For example, the development and popularization of the Internet has led to the appearance of social networking platforms such as Twitter and Renren. Initially, when the situation was not clear, many people chose to wait rather than join these networks immediately. And, after waiting for a period of time, the decision makers were likely to choose the social platform selected by most of their friends and herd behaviors may occur.

Therefore, in this study, we construct a generalized WB model (G-WB model), where we consider a more general situation for technology adoption and incorporate a waiting strategy. In the G-WB model, as well as selecting a specific technology that is considered to be desirable, the decision makers can wait if they are in a dilemma. We also test the G-WB model with an increased number of decisions to determine whether herd behaviors emerge, as well as addressing the controversial question of the relationship between herding and information cascades. We then investigate the effects of different parameters in our model on the convergence speed. Moreover, we show that the G-WB model is an optimal version of the WB model in terms of both accuracy and robustness. Finally, we extend the model in three respects: (a) decision makers have different preferences; (b) incomplete information is available when the decision makers observe actions in a group; and (c) the decision makers have limited rationality, where we analyze the effects of these changes on convergence.

The remainder of this paper is organized as follows: In the next section, we present background material about IT adoption and social learning. Next, we describe the proposed G-WB model in Section 3. In Section 4, we analyze the G-WB model, before extending this model in Section 5. Finally, we give our conclusions in Section 6.

2. Background

Given the rapid development of IT/IS, the range of services available to human society has expanded, initially for national defense and military applications but then for industrial and commercial uses, while it now supports people in all workplaces to improve the efficiency of work, as well as enriching our daily lives, leisure pursuits, and other forms of entertainment. IT adoption can be classified as individual, group, and organizational level adoption, depending on the type of IT application that is being adopted. IT adoption can also be divided into work applications and those related to other aspects of our daily lives and entertainment.

Software and other technological components are among the most complex artifacts that humans have ever built [13]. It may take many years to realize the impact of technologies [9], where the benefits of adopting useful technology can be tremendous, but the costs of adopting a failing technology can be severe. The wide scope, complexity, and high uncertainty of IT/IS applications mean that technology adoption can be a difficult issue for the decision makers. Therefore, the study of IT adoption has been a major issue since the mid-1980s. Technology adoption research in this area has focused on two main strands: studies based on classical theory and research combined with theory from other disciplines.

The classical theory of IT adoption involves the research areas such as the technology adoption model (TAM), innovation diffusion theory (IDT), and the theory of planned behavior. Davis [24] proposed TAM and validated new measurement scales for the perceived usefulness and perceived ease of use, which are two distinct variables that are hypothesized to be determinants of computer usage. The IDT can be used to predict an individual's adoption behavior, where it is proposed that beliefs affect attitudes, which then influence intentions, and thus behavior [8]. Ajzen [14] suggested that different types of behaviors can be predicted with high accuracy from attitudes toward behavior, subjective norms, and perceived behavioral control. Attitudes, subjective norms, and perceived behavioral control are also related to appropriate sets of salient behavioral, normative, and control beliefs regarding behavior, but the exact natures of these relationships are still uncertain. In addition to classical technology adoption theories, many other theories are used to analyze IT adoption from different perspectives, such as transaction cost theory in economics, cognitive theory in psychology, and change management theory in organization research.

In this study, we consider technology adoption based on social learning, where word-of-mouth learning is another typical form of social learning in addition to observational learning. However, the information acquired from word-of-month learning may be unreliable because no hard evidence is provided, and opinions may not be supported by reasons, and thus it is not possible to observe the entire process based on the information provided. Moreover, it is not possible to believe everything that one is told both because hard evidence is often lacking and people often attach their personal hopes and fears to the information that they report [3]. Therefore, word-of-mouth information may sometimes be distorted, especially when it is spread sequentially among people. Indeed, "actions speak louder than words," so the decision makers are more likely to observe the actions of others in similar situations to acquire information and make optimal decisions, i.e., observational learning. Research has shown that people use observations of others to update their own private beliefs and take actions [1], and observational learning is even more important than professional reviews for explaining technology adoption [20]. Thus, observation learning is one of the most ubiquitous and useful means available to the decision makers.

Laboratory and real world studies have shown that observational learning influences the decision makers during technology adoption. With the maturation of electronic commerce, peer-to-peer (P2P) internet technology now allows client machines to interact directly with each other. Thus, many people are faced with the decision of whether to adopt this new technology. Song and