Australasian Marketing Journal 22 (2014) 69–72

Contents lists available at ScienceDirect

Australasian Marketing Journal

journal homepage: www.elsevier.com/locate/amj

From i-phone 3G to i-phone 4G: A two-stage complex systems model of the two stage diffusion process

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ARTICLE INFO

Article history:
Available online 25 January 2014

Keywords:
Complexity Theory
Agent-based modelling
Diffusion

ABSTRACT

We present a conceptual model where agents are prompted to adopt a new technology through a two-step process: information from neighbours prompts an upgrade, and the option purchased may be influenced by the one demonstrated by the neighbour. In a network world with two options available we systematically manipulate (1) the initial number of neighbours with white compared to black, (2) rate of naturally-occurring upgrade, (3) chance of upgrade prompted by a neighbour using white relative to black, and (4) the relative chance of choosing white instead of black having decided to upgrade. Not surprisingly, adoption speed is influenced by starting users, natural upgrade, and relative upgrade chance. Market share, on the other hand, is influenced only by the relative chance of choosing white over black, with no influence at all from the other predictors. We find that this result applies regardless of the type or complexity of network.

摘 要

我们展现的是通过两阶段过程，促使主体采纳新技术的观念模型；相邻的信息提示一个商品更新，购买的商品可能受到近邻显示的商品影响。在网络世界提供两个选项的情况下，我们系统地处理（1）近邻黑白分明的原始数量，(2) 自然发生的更新率，(3) 近邻采用的黑白相关的信息提示的更新可能性，及（4）决定更新后，选择白而不选择黑的相关可能性。毫不奇怪，初始用户、自然更新和相关的更新可能性影响着采纳的速度。另一方面，市场份额仅受选择白超过选择黑的相关可能性的影响， 完全不会受到其它预测因素的影响。我们发现这个结果适用于各种网络类型或网络的复杂性。

1. Introduction

Steenkamp et al. (1999) estimated that two thirds of new products fail, at an average cost of around $US 15 million for each such product. However, they also noted that many major companies, such as Gillette and Hewlett–Packard, rely on new products for profits and growth. Thus, consumer's acceptance of new products is vital, which means a greater understanding of the consumer diffusion process is crucially important to many organizations.

Typically, the innovation process has been studied as process of interpersonal influence, where opinion leaders help spread the acceptance of an innovation (Rodgers, 1995). Opinion leaders spread an innovation more effectively than the mass media by visible demonstration or by word-of-mouth communication. They are crucial change-agents who champion innovation and are well positioned to become aware of and adopt innovations (Chua and Hui, 1998). It is possible though, that acceptance of an innovation may be considered as a two-stage process, where there is both the social pressures to "upgrade" technology, and then the type of model or design of the new product that is selected (Lam et al., 2010; Woisetschläger et al., 2011). One may argue that it is the acceptance of a particular brand of product, rather than new technology, per-say, is the real focus of diffusion-of-innovation studies in marketing. Scholars have argued that the social process of the acceptance or rejection of a two-stage process of innovation (new product and product variant) is best studied by analysing social networks (Goldenberg et al., 2002; Bohlmann et al., 2010). These social networks are best studied as dynamic and complex structures by the use of agent-based modelling (ABM). Rand and Rust (2011), list application areas suitable for ABM as; diffusion of information and innovations, retail location decisions, inter-firm relationships, strategy and competition, marketing mix models and retail and servicescape design. In relation to this study, (Goldenberg et al., 1999) note that many new innovations and product

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http://dx.doi.org/10.1016/j.ausmj.2013.12.011

choices in markets can be modelled accurately with as few as six parameters.

2. Cellular automata – agent-based modelling

In the present context, we use ABM to study a two-stage adoption effect: for example, deciding to buy a tablet computer and then choosing between an Apple iPad and a Samsung Galaxy. For simplicity's sake we consider upgrading from a 3G to a 4G iPhone and the choice of either a white or black colour handset. We were particularly interested in how signalling (of say, a white phone compared to a black phone) triggers the decision to adopt and what model was then selected. This is analogous to a brand choice following on from a decision to upgrade to the latest technology. It has also been suggested that the degree of consumer confusion over the myriad of marketing offers leads them to rely on very simple strategies such as seeking word-of-mouth information or advice (Turnbull et al., 2000), which means social network effects are likely to be important in explaining two-stage diffusion-of-innovation behaviour. The key research objectives of the study are therefore:

(1) Model the effect of brand choices (white or black) in social networks as to how it influences the rate of acceptance of new technology (4G versus 3G).
(2) Model how the brand choices of agents (white or black) affect the brand choices of other agents' new technological upgrades.
(3) Examine how 1 and 2, above, are affected by different types of social networks (which model the effect of different personal influence structures).

Agent-based models are generally computer-based simulations of complex systems. Typically independent "agents" operate concurrently and interact with each other in space and time. This makes it possible to explore the connection between the micro-level behaviour of individuals and the macro-level patterns that emerge from the interaction of many individuals (Wilensky, 1999). Where economists and financial analysts in the past have regarded a marketplace as a single object to be analysed with a mathematical equation, Complexity Theory recognises that a marketplace is simply the aggregation of individual behaviours. Cellular automata are the tool for which we can model or simulate behaviour at the level of the individual and observe their aggregation.

3. The models

The authors chose to use NetLogo (Wilensky, 1999) for this study. NetLogo is a programmable modelling environment for simulating natural and social phenomena. NetLogo is freely available. Two Netlogo models use in this study consisted of the following parameters:

Each agent, or "turtle", owns a 3G phone. Each has an independent chance of upgrading to a 4G phone, say when a contract expires (stage one of the acceptance process). Having decided to upgrade, there is an independent chance of choosing white or black. Connected neighbours can affect the chance of upgrading. A neighbour who owns the new phone is likely to influence an agent. The model owned may differentially affect upgrade likelihood. For example, an owner modelling a white phone may prompt upgrade more than the owner of a black phone. There is also a possibility of imitation from a neighbour owning a white or black iPhone. These values can be adjusted so that the effect of individual versus interpersonal influence can be modelled.

Two different social networks are modelled. Fig. 1 (colour removed) illustrates a random network, with variation in the average node degree (average number of connections for each agent). In such a network, frequently used for virus dispersion models, some nodes may be isolated in distinct islands not-connected with other nodes. The second social network, in Fig. 2, is a scale-free network created using preferential-attachment connections where all nodes are connected, and some nodes are hubs connecting large numbers of other nodes.

The two network structures are very different. A Random network does not guarantee that there is a link between any one agent and all other agents. In such a model, then, we should expect to see slower diffusion as a result of modelling and imitation. The scale-free network, on the other hand, has all nodes connected to all other nodes.

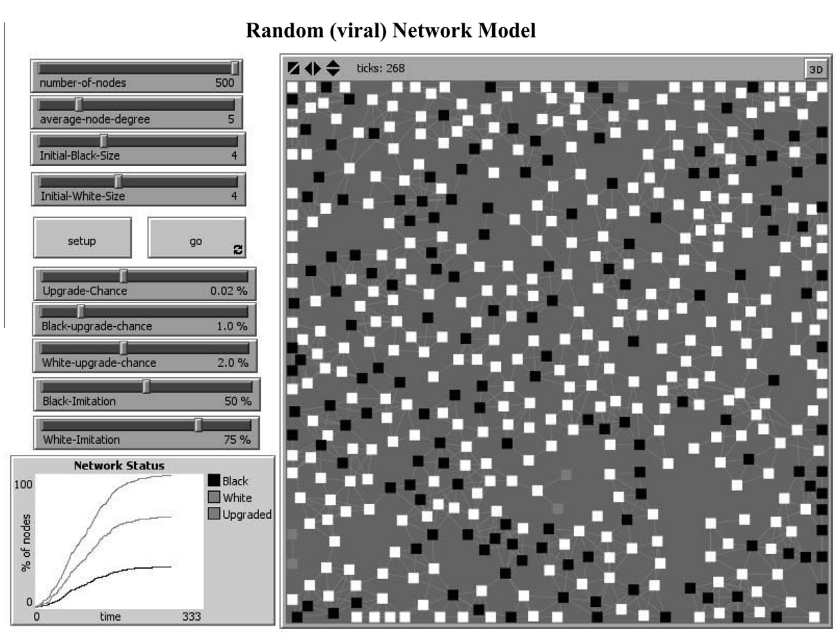

Fig. 1. Random (viral) network model.